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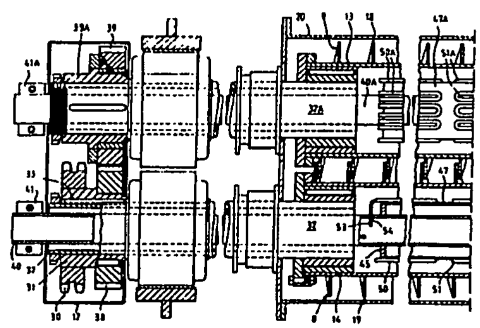
(54) Title: APPARATUS FOR CONTINUOUSLY MIXING AND HEATING FLOWABLE MATERIALS

(57) Abstract

An apparatus for continuously mixing and heating flowable materials comprising an inclined housing (20), at least two rotatable screws within said housing, each screw having a rotatably mounted shaft (14, 13) and a screw flight (18, 19), said screws being arranged in parallel juxtaposition with their respective flights of opposite hand intermeshing, and means for driving said shafts in opposite rotation to each other, characterised in that each rotatably mounted shaft (13, 14) is hollow, and that there are provided electric heaters (50) respectively within said hollow shafts.



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APPARATUS FOR CONTINUOUSLY MIXING AND HEATING FLOWABLE MATERIALS

This invention relates to apparatus for continuously mixing and heating flowable materials such as liquids, powders, granular materials and other flowable materials including cakes, and residues.

Apparatus comprising a screw in a casing for conveying such materials is well known. It is also known that such screws may comprise a rotating hollow shaft carrying a hollow screw flight through which heat transfer media may be passed for heating the conveyed material. However for heating some materials steam or oil heating is not particularly practicable. For instance, pyrolysing treatment of pulverised coal requires a pyrolysing temperature of about one thousand degrees Fahrenheit. For this purpose a single screw device was tried many years ago in which the screw rotated alternately clockwise and anticlockwise but its use was discontinued long ago so presumably it was inefficient.

Heating hollow screws by steam or hot oil was unlikely to be suitable for such high temperatures. An alternative would be to pass molten salts through hollow screws. This has been tried, but unless the salt is totally evacuated from the screws on the shutdown, it freezes solid which involves considerable difficulties.

Another possibility could be to incorporate electrically heated rods in the shafts carrying the screw flights but this also involves practical difficulties and is

of doubtful efficiency.

The object of the present invention is to devise improved apparatus for continuously mixing and heating flowable materials.

A further object of the invention is to provide more efficient heating means for heating a casing incorporating a pair of rotating screws having screw flights of one interleaving with the screw flights of the other so as to effect a mixing of the materials with enhanced uniformity of heating.

According to the present invention there is provided an apparatus for continuously mixing and heating flowable materials comprising an inclined housing, at least two rotatable screws within said housing, each screw having a rotatably mounted shaft and a screw flight, said screws being arranged in parallel juxtaposition with their respective flights of opposite hand intermeshing, and means for driving said shafts in opposite rotation to each other, characterised in that each rotatably mounted shaft is hollow, and that there are provided electric heaters respectively within said hollow shafts.

This arrangement has been tested and found to be most surprisingly efficient and practicable.

Further according to the invention fixed support shafts extend within said rotatably mounted shafts which carry said heaters secured thereon.

Also, according to the invention said support shafts

may each carry a hollow cylinder on the exterior surface of which is mounted said heater.

The additional heater shaft with heating elements may be provided in each of a pair of interleaved rotatable shafts.

The invention will be further described by way of example with reference to the accompanying diagrammatic drawings wherein:

FIGURE 1 (1A and 1B) is an elevational view of a screw conveying apparatus made in accordance with the invention;

FIGURE 2 (2A and 2B) is a sectional view on the plane 2-2 on Figure 1;

FIGURE 3 is a sectional view on the plane 3-3 on Figure 1, and

FIGURE 4 shows a sectional view of a modification of the apparatus in which four screws are provided.

The apparatus comprises a base 10, a support 11 having an inclined upper track 11a, an upright drive bearing housing 12 mounted on rollers 12a engaging said track 11a to permit movement of said housing to accommodate expansion and contraction of the apparatus, a casing 20, and screws 8, 9 within said casing arranged in parallel juxtaposition relative to each other and inclined at 3 to 25%.

The screws 8, 9 comprise respectively rotatable hollow shafts 13, 14 and screw flights 18, 19 fixed thereon. The casing 20 which in turn is preferably arranged within a

heat insulating jacket 21, is mounted at the lower end on a fixed part of the bearing housing 12 and at its upper end on a fixed part of a bearing housing 23 at the upper delivery end. The jacket 21 is provided with openings 22, 26 for the purpose of the removal of vapour or for visual inspection.

The screws 8, 9 are mutually spaced so that the screws intermesh with their flights mutually overlapping (i e interleaved) and in close proximity to each other but not touching.

The housing 20 has an inlet 26 at its lower end in which material to be treated is introduced. An outlet chute 28 at the upper end of the housing 20 leads to an inlet cooling conveyor 29, which may be one of several known types.

As shown in Figure 2A the gear housing 12 contains an input sprocket 30 on a hub 31 which is keyed to a stub axle shaft 32 by a key 33. The hub carries a gearwheel 38 which meshes with a gearwheel 39 which rides freely on hub 39A over a limited arc to form part of a lost motion device, which shaft 39A is connected to a shaft hollow 32A. The stub axle shafts 32, 32A are connected respectively by bushes and keys to the screw shafts 14, 13. The intermeshing gears are driven in opposite directions.

The shafts 13, 14 are connected at the output end by rings 34, 34A and plates 35, 35A to shafts 36, 36A mounted in bearings 37, 37A.

Located coaxially within the hollow shafts 32, 32A; 14, 13; 36, 36A; and spaced from the shaft 14; 13 are

respectively provided non-rotatable hollow shafts 40, 40A supported beyond the shafts 32, 32A; 14, 13; by a support 41, 41A at one end and a support 42, 42A at the other end.

Within each hollow shaft 13, 14 and fixed to the shaft 40 are plates 45, 46 spaced apart and carrying a hollow cylinder 47 which extends over a major portion of the axial length of the shaft 13, 14. Fixed in the outside of the hollow cylinder are a series of electric heater U-shaped or straight elements 50 at one end and a similar series of electric heater elements 51 at the other end. The elements 50, 51 have electrical connections 53, 56 which pass through holes 54, 55 into the interior of the shaft 40 where they pass axially through to an exterior source of electricity supply.

Although U-shaped elements are shown for two separately controlled heating zones, straight tubes for single control may also be used.

The heat from the elements is transmitted by radiation to the shafts 13, 14 and the flights 18, 19 also become heated so that by the heated shafts and flights, assisted by the mixing action, the coal particles or other materials are efficiently raised to the required high temperature.

An alternative embodiment is shown in Figure 4, which may embody any of the features of the example described with reference to Figures 1 to 3. In this arrangement further flighted screws (62, 63) are provided within said

housing 20 on axes parallel to the axes of the opposite hand intermeshing screws 60, 61, said further screws respectively interleaving with the intermeshing screws 60, 61 and being of the same pitch and hand thereof and serving to clean the flights of said intermeshing screws. The further screws may or may not have heaters.

The use of four screws achieves a doubling of the throughput capacity over the twin screw apparatus.

In another modification the outer screws may be multiple lead or extended lead screws driven at different speeds.

In operation material fed to the lower end of the apparatus by way of the inlet 26 may be gathered up by the intermeshing screws 8, 9; 60, 61 from beneath on commencement of rotation. For ease of operation and to prevent jamming, the rotational direction is reversed after several revolutions, whereafter the screws are again driven in a forward and upward feed movement.

It is preferable that the drive mechanism for the screws be provided within the lowermost bearing housing which, due to the extension of the stub shafts, can be disposed at a distance from the screw housing. In this way, the drive mechanism is not exposed to the heat from the hot gases which are at their higher temperature at the delivery end of the housing.

By fixing the heating elements relative to the rotating screws efficient and uniform heating of the screws

is achieved. Connection of the elements is simply achieved. Further, the elements may also be readily removed for maintenance or change of heat output rating.

The apparatus described in the above examples may be used for the pyrolysing of coal products to drive off unwanted moisture. In this case, as shown in Figure 3, gas burners 70 may also be used. However, for the treatment of oil residues (known as "bottoms") the burners are not required.

For the treatment of "bottoms" the apparatus is equipped to operate at temperatures in the region of 1200°F (649°C). The finely granular product is found to be uniformly dry.

CLAIMS:

1. An apparatus for continuously mixing and heating flowable materials comprising an inclined housing (20), at least two rotatable screws within said housing, each screw having a rotatably mounted shaft (14, 13) and a screw flight (18, 19), said screws being arranged in parallel juxtaposition with their respective flights of opposite hand intermeshing, and means for driving said shafts in opposite rotation to each other, characterised in that each rotatably mounted shaft (13, 14) is hollow, and that there are provided electric heaters (50) respectively within said hollow shafts.

2. An apparatus as claimed in claim 1, characterised in that fixed support shafts (40) extend within said rotatably mounted shafts (13, 14) which carry said heaters (50) secured thereon.

3. An apparatus as claimed in claim 2, characterised in that said support shafts (40) each carry a hollow cylinder (47) on the exterior surface of which is mounted said heater (50).

4. An apparatus as claimed in claim 3, characterised in that said heater comprises a plurality of elongate heating elements (50) arranged axially of the cylinder (47).

5. An apparatus as claimed in claim 4, characterised in that said elongate heating elements (50) are connected in pairs so as to be substantially U-shaped.

6. An apparatus as claimed in claim 5, characterised in that the U-shaped heating elements are arranged in two groups provided one at each end of the cylinder (47) and together extending substantially the entire length of the cylinder (47).

7. An apparatus as claimed in claim 4, 5 or 6, characterised in that the hollow cylinder (47) and the elongate elements (50) are contained wholly within the rotatably mounted shafts (14, 13) respectively and extend over a major portion of the axial length of said shafts.

8. An apparatus as claimed in claim 7, characterised in that connections (53, 56) for said elements pass through holes (54, 55) in said support shafts (40) and axially therethrough to an exterior source of electrical supply.

9. An apparatus as claimed in any one of claims 1 to 8, characterised in that pairs of hollow stub axles (32, 32A; 36, 36A) serve to carry said screws, which axles are drivably connected to the hollow shafts (14, 13) of the screws (8, 9), and bearing housings (12, 21) serve to support the stub axles at the upper and lower ends of the screws.

10. An apparatus as claimed in claim 9, characterised in that said driving means is provided within the lowermost bearing housing (12).

11. An apparatus as claimed in claim 10, characterised in that said driving means comprises a pair of hubs (38, 39), a pair of intermeshing gear wheels (38, 19),

mounted on said hubs respectively, and an input drive sprocket (30) mounted on one of said hubs.

12. An apparatus as claimed in claim 10 or 11, characterised in that the lowermost housing (12) is mounted on rollers (12a) which run on an inclined track (11a).

13. An apparatus as claimed in any one of claims 9 to 12, characterised in that a heat insulating jacket is supported between the upper and lower bearing housings (12, 23), said jacket surrounding the housing (20) and screws (8, 9).

14. An apparatus as claimed in any one of claims 1 to 13, characterised in that further flighted screws (62, 63) are provided within said housing (20) on axes parallel to the axes of the opposite hand intermeshing screws (60, 61), said further screws respectively interleaving with the intermeshing screws (60, 61) and being of the same pitch and hand thereof and serving to clean the flights of said intermeshing screws.

15. An apparatus as claimed in any one of claims 1 to 14, characterised in that the axes of the screws are inclined at 3 to 25%.

16. An apparatus as claimed in any one of claims 1 to 15, characterised in that the housing in the region beneath the screws is spaced in close proximity thereto and follows the overall profile of the screws considered axially.

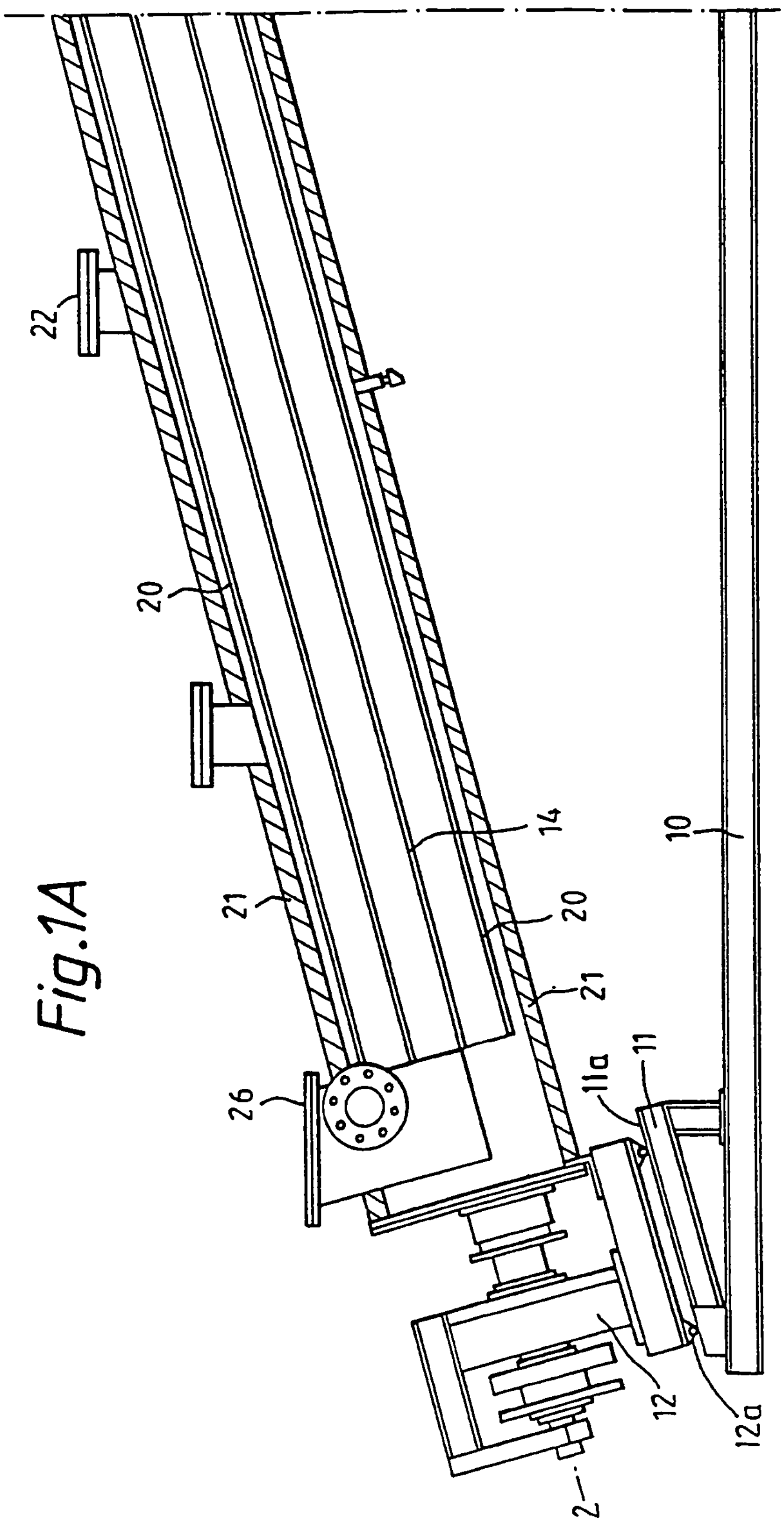


Fig.1A

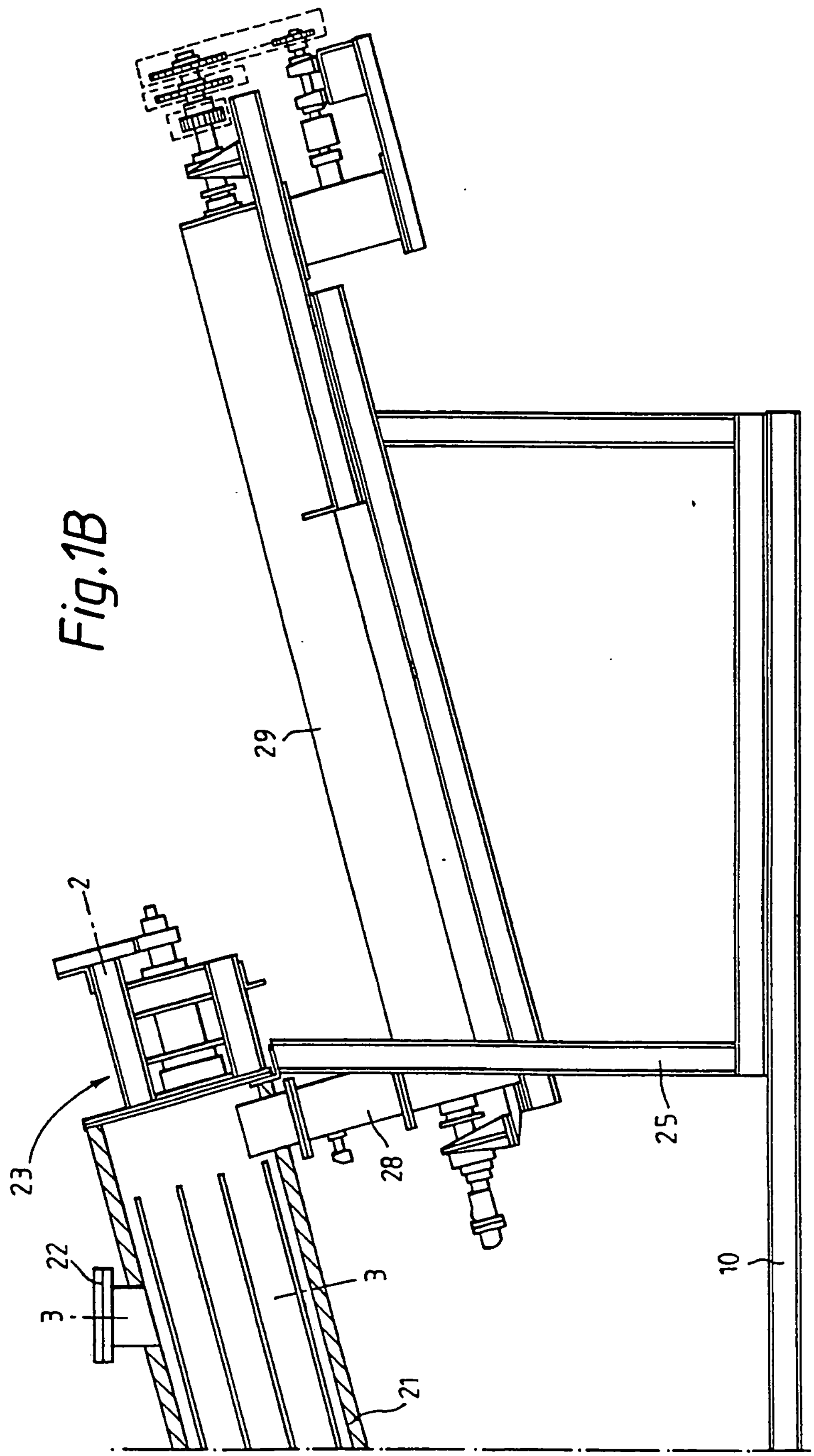
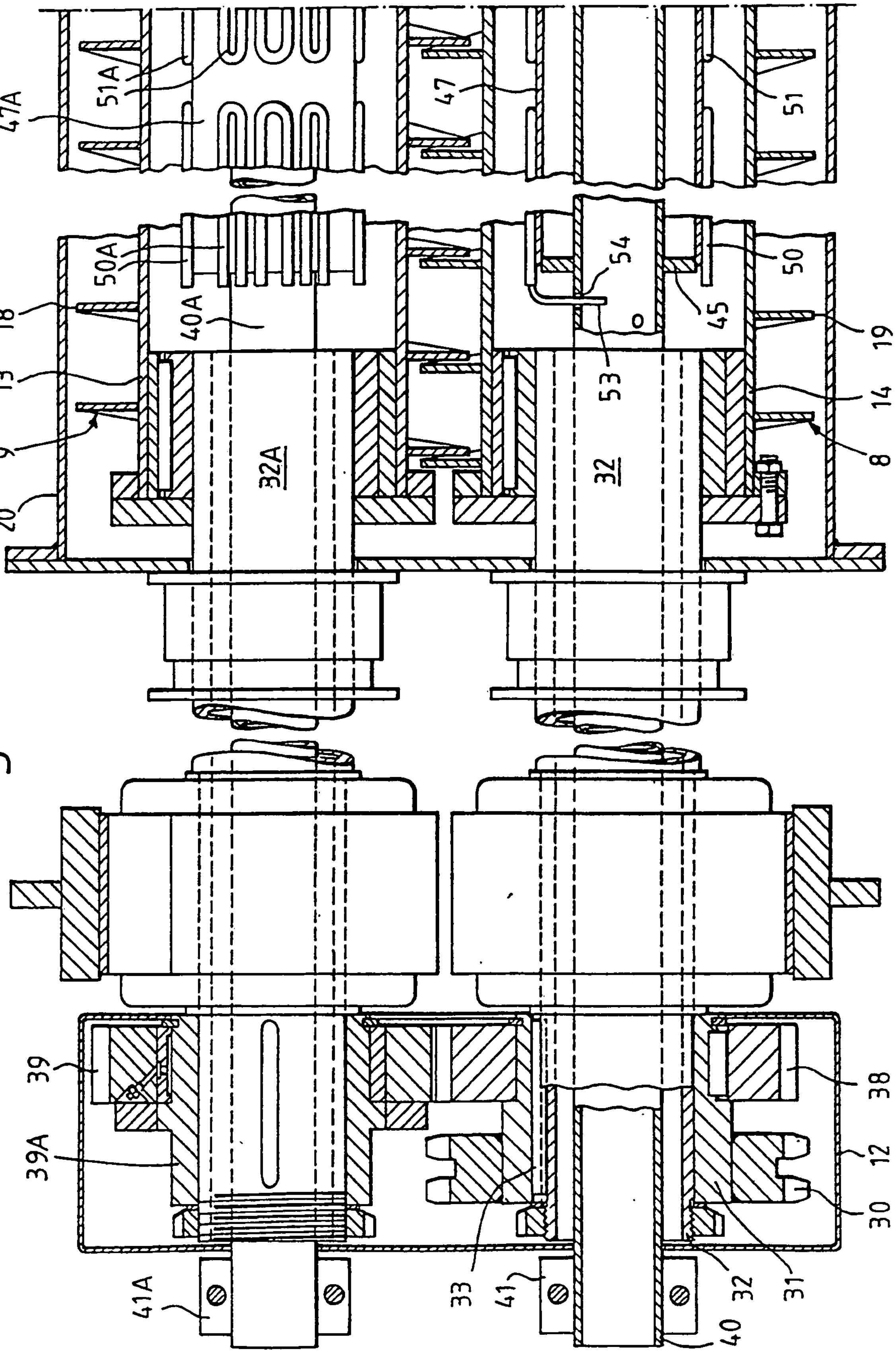


Fig.1B

Fig. 2A


47A
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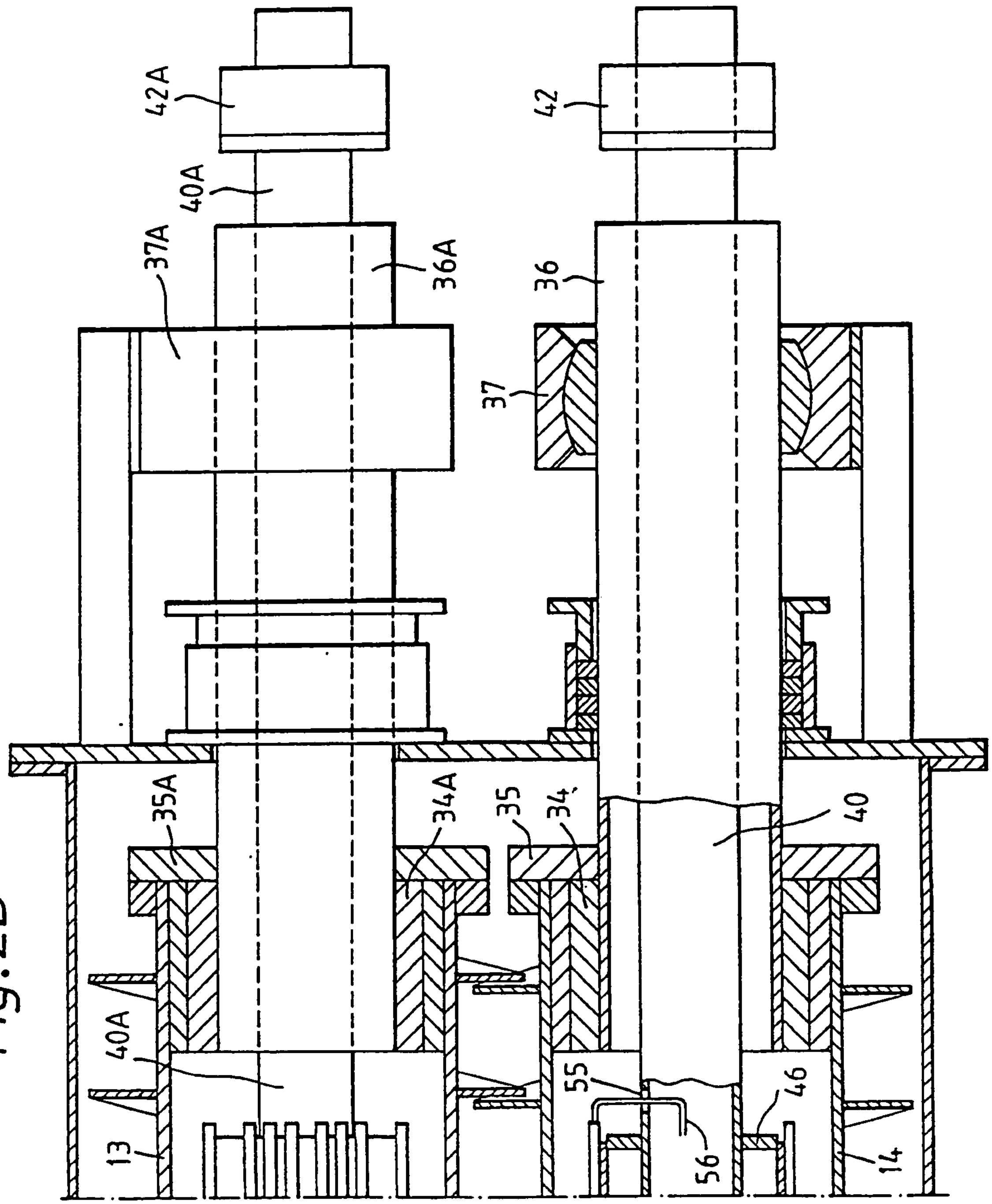


Fig. 2B

Fig.3

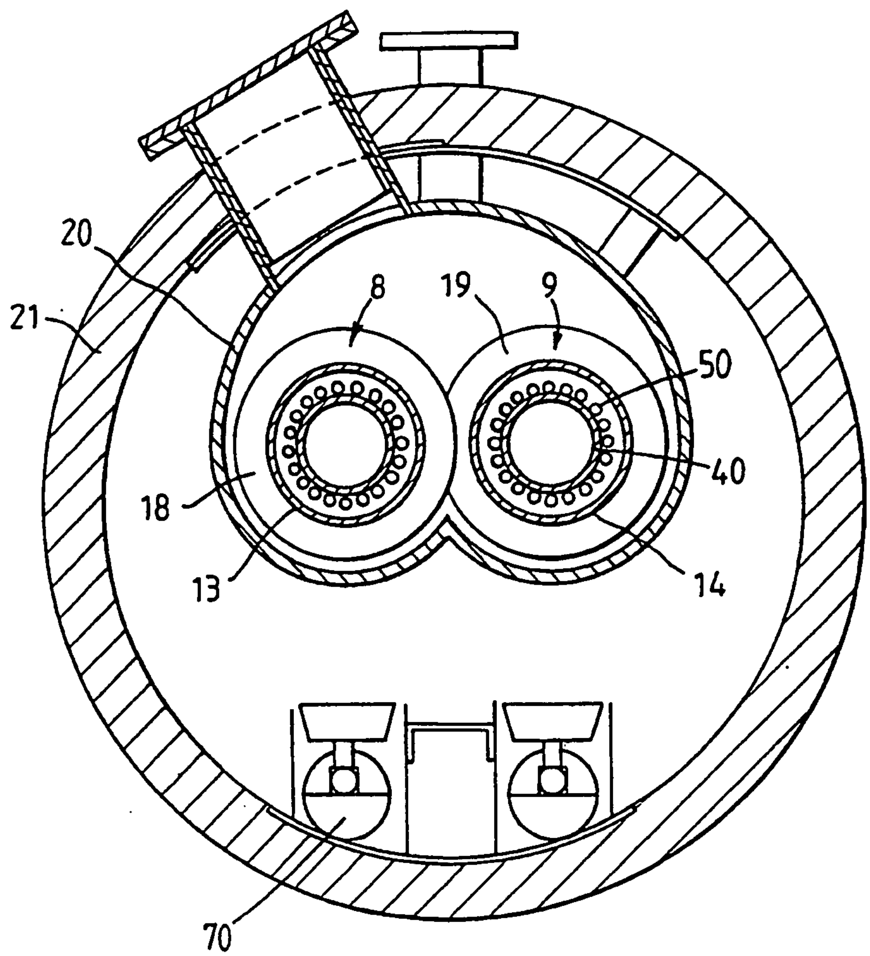
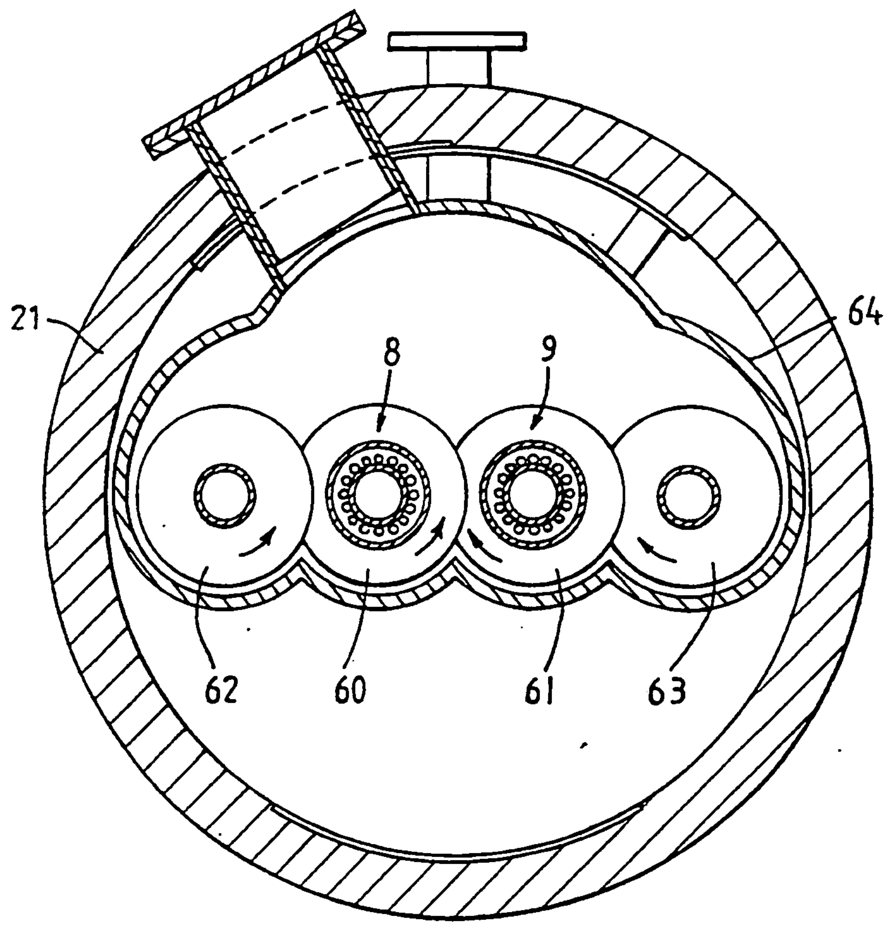


Fig.4



INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 92/00676

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl. 5 B01F15/06

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
Int.Cl. 5	B01F ; B29C ; F26B

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched[8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category °	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No.[13]
X	US,A,3 589 834 (CAIRELLI) 29 June 1971 see claim 1 ---	1
X	US,A,3 884 607 (GERHARDS) 20 May 1975 ---	1,4
A	US,A,3 525 124 (OCKER) 25 August 1970 see figure 10 ---	14,16
A	US,A,3 457 989 (NONNENMACHER) 29 July 1969 ---	
A	US,A,3 255 815 (SMITH) 14 June 1966 ---	

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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
27 JULY 1992	05. 08. 92
International Searching Authority	**Signature of Authorized Officer**
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ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO. GB 9200676 SA 58451

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
The members are as contained in the European Patent Office EDP file on 27/07/92
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